

NASA Global Flood Mapping System

Fritz Policelli, NASA GSFC

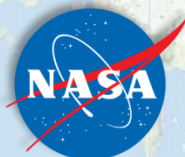
Dan Slayback, SSAI/ GSFC

Bob Brakenridge, University of Colorado

Joe Nigro, SSAI/ GSFC

Alfred Hubbard, SSAI/GSFC

September __, 2017

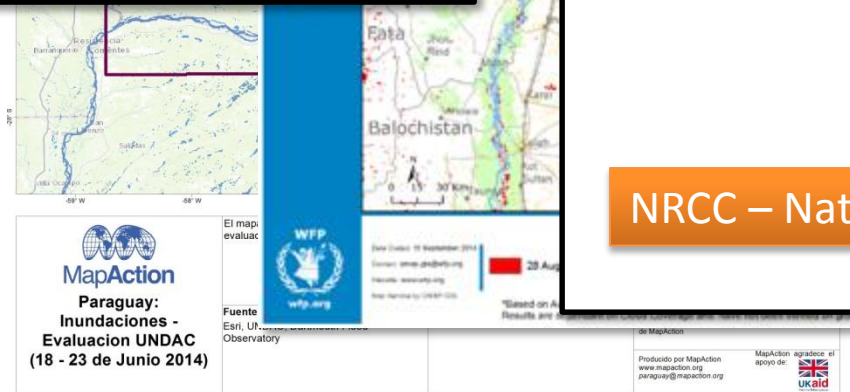
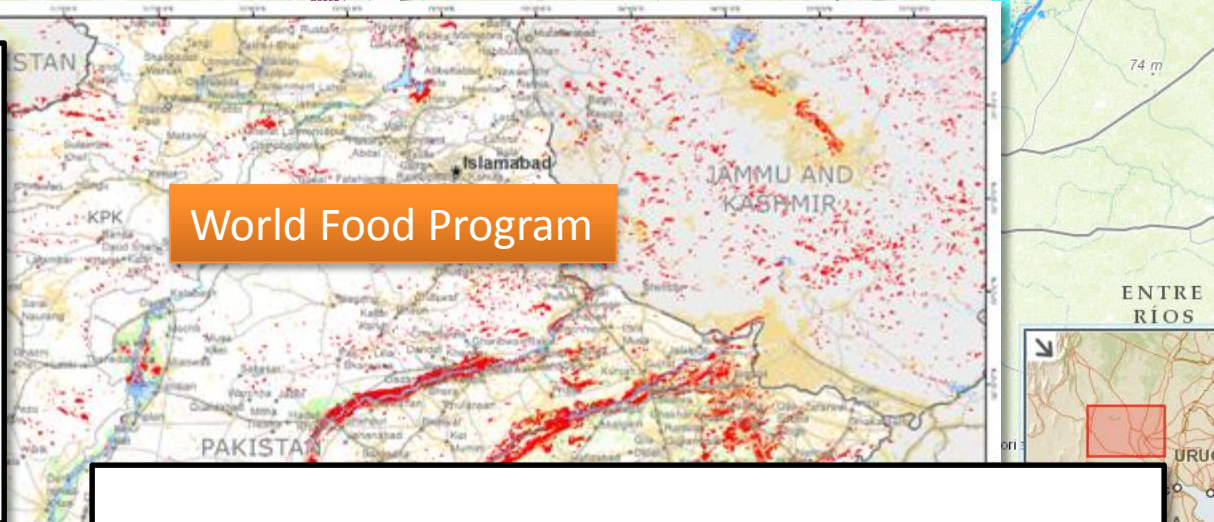
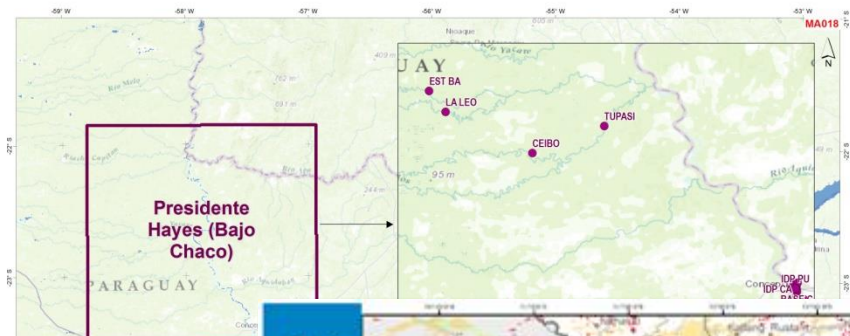


**Goddard Space Flight Center
Hydrological Sciences Lab**



**Dartmouth
Flood Observatory**

Selection of users



NRCC – National Response Coordination Center

Product utility – key factors

- Near real time, automated production
- Flood spatial extent
- Cloudiness
- Pixel resolution: 250m
- Flood temporal extent
 - Flash floods / short duration on ground?
- Landcover
 - Water under vegetation cover vs open water

A little history

- Bob Brakenridge (Dartmouth Flood Observatory) manually generated flood maps using MODIS rapid response imagery
 - Product distribution via large-format digital maps (tif and pdf)
 - Useful product, but:
 - Generated from rapid response jpegs not meant for analysis
 - Not automated
 - Not easily incorporated into GIS
- NASA funded GSFC to build an automated daily, global, near real-time system



Terra

The MODIS sensor is on both the NASA Terra and Aqua satellites



Aqua

MODIS product distribution system:

<http://oas.gsfc.nasa.gov/floodmap>

NRT Global Flood Mapping

South America

090W 080W 070W
020N 020N 020N

090W 080W 070W 060W
010N 010N 010N 010N

090W 080W 070W 060W 050W 040W
000S 000S 000S 000S 000S 000S

080W 070W 060W 050W 040W
010S 010S 010S 010S 010S

080W 070W 060W 050W 040W
020S 020S 020S 020S 020S

080W 070W 060W
030S 030S 030S

080W 070W
040S 040S

080W 070W
050S 050S

For more information, please contact floodmap at lists.nasa.gov

NOTE: THIS IS AN EXPERIMENTAL PRODUCT AND SYSTEM

NASA Official: Frederick Policelli
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Data Viewer
Africa
Asia
Australia/NZ
Europe
North America
South America

Product Description Documents
Project Summary
MODIS Product README
Evaluation Report
Presentations

Future Enhancements
News/Status

Mailing list
To subscribe to our mailing list to receive email notification of updates, please, click [here](#).

3 Day Composite 2 Day Composite 1 Day Composite 14 Day Composite

« August 2017 »
S M T W T F S
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31

Products
MODIS Flood Map MFM
MODIS Flood Water MFW
MODIS Surface Water MSW
MODIS Water Product MWP
README

Available Downloads
png
shapefile (.zip) KMZ
shapefile (.zip) KMZ
geotiff
pdf txt

MODIS Flood Map
9-11 Aug 2017
Title: 060W030S

Current floodwater
Input: LANCE MODIS

Cloud
MODIS / MOD35

Reference water
MOD44W lakes
Natural Earth rivers

Urban areas

Background:
US NPS World Physical Map

100 km Projection: Pseudo-Cylindrical, WGS-84

NASA GSFC Flood Mapping Project
NASA Goddard Space Flight Center
Greenbelt MD 20771 USA

Product: 30307 / 303233
Generated: 11 Aug 2017 23:22:43 GMT

Continental tile index

Specific tile

- Date selector
- Available product/format downloads

MODIS Flood Product

Input data: near real-time MODIS imagery from the LANCE system at NASA Goddard Space Flight Center

- Daily calibrated Terra and Aqua MODIS reflectances for bands 1, 2,7
- Corresponding cloud products for cloud and cloud shadow masking
- Delivered in 10 deg. X 10 deg. tiles

Water detection algorithm

Water if: $\frac{(Band2+A)}{(Band1+B)} < C$

AND $Band1 < D$

AND $Band7 < E$

A	13.5
B	1081
C	0.7
D	2027
E	676

- Bands are MOD09 surface reflectance product
- **Developed by Bob Brakenridge, Dartmouth Flood Observatory, U. Colorado**

Additional Processing

- Multi-look compositing: require multiple positive water detections to label a pixel as water – minimizes cloud shadow false-positives
- Terrain shadows masked using DEM and solar geometry
- Flood: water exceeding normal surface water, as defined by static global water map (MOD44W)

Automated MODIS Flood Map Production System

- Fully automated (since Nov 2011)
- 223 $10 \times 10^\circ$ tiles x 3 products (2-day, 3-day, 14-day) = 669 daily product suite generated
- Product suite includes: geotiffs, shapefiles, KML (Google Earth), and graphic maps (png)
- Products typically available within 6 hours of Aqua overpass (~ 8:00 PM local time)
- Delivery via web download

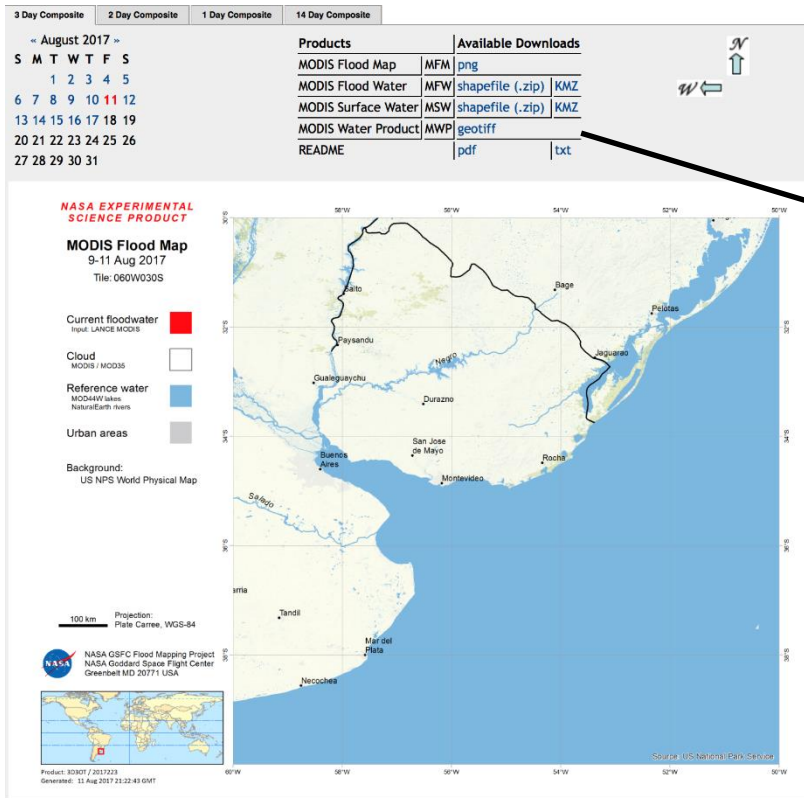
Products: 3 elements

1. Composite period (balance between currency and spatial completeness):
 - Standard products: 2-day, 3-day
 - Short-term: 1-day
 - Extended: 14-day
2. Product name:
 - MWP: MODIS Water Product (core product)
 - MFW: MODIS Flood Water (derived)
 - MSW: MODIS Surface Water (derived)
 - MFM: MODIS Flood Map (derived)
3. Formats:
 - Raster / geotiff (some products)
 - Vector / shapefile & KML (some products)
 - Graphic product/ png

MODIS Flood Map Compositing

- 1-day composite: requires 1 water observation over current day's imagery (potentially 2 observations with Terra and Aqua). **Not normally generated.**
- 2-day: requires 2 water observations over 2 days of imagery (potentially 4 observations).
- 3-day: requires 3 water observations over 3 days of imagery (potentially 6 observations).
- 14-day: second order composite, combining the 14 previous 3-day products. Provides a recent-historical view.

Distribution via NASA website: <http://oas.gsfc.nasa.gov/floodmap>



Products		Available Downloads	
MODIS Flood Map	MFM	png	
MODIS Flood Water	MFW	shapefile (.zip)	KMZ
MODIS Surface Water	MSW	shapefile (.zip)	KMZ
MODIS Water Product	MWP	geotiff	
README		pdf	txt

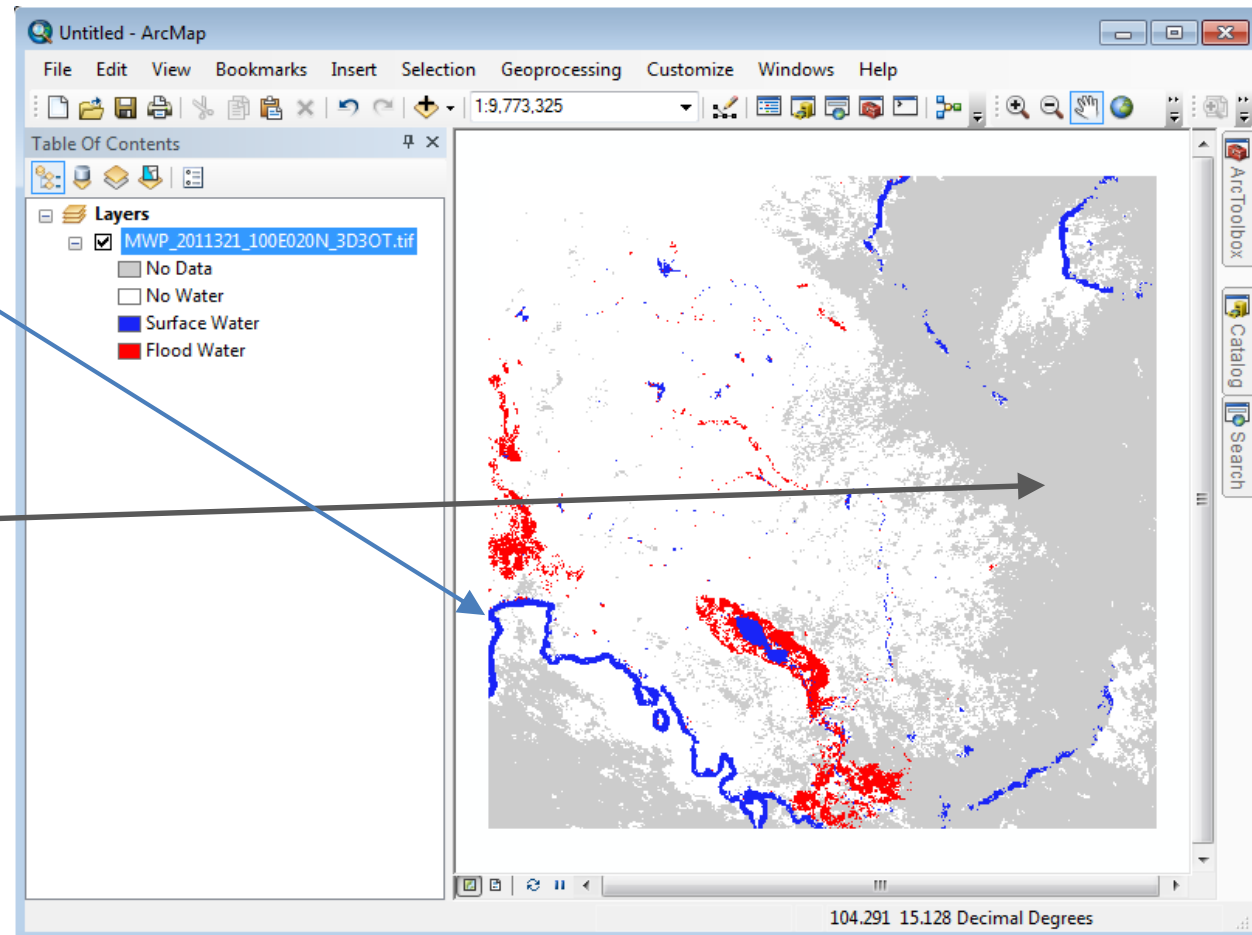
Product downloads table

060W030S

- date selector
- product/format downloads
- navigation tool

Products: MODIS Water Product (MWP)

- Core product
- Geotiff format
- Values:
 - 0: Insufficient data (for composite period)
 - 1: No water detected
 - 2: Surface water (corresponding to Reference water pixels).
 - 3: Flood water (water outside Reference water pixels).
- Coastal strip visible; ocean water removed beyond 10 km
- MOD35 Cloud used only to populate "Insufficient data"; water detected through cloud IS reported



Products: MODIS Flood Map (MFM) 10° tile graphic map (PNG)

**NASA EXPERIMENTAL
SCIENCE PRODUCT**

MODIS Flood Map

1-2 Nov 2011

Tile: 100E020N

Current floodwater

Input: LANCE MODIS



Cloud

MODIS / MOD35



Reference water

MOD44W lakes
NaturalEarth rivers



Urban areas



Background:

US NPS World Physical Map

100 km

Projection:

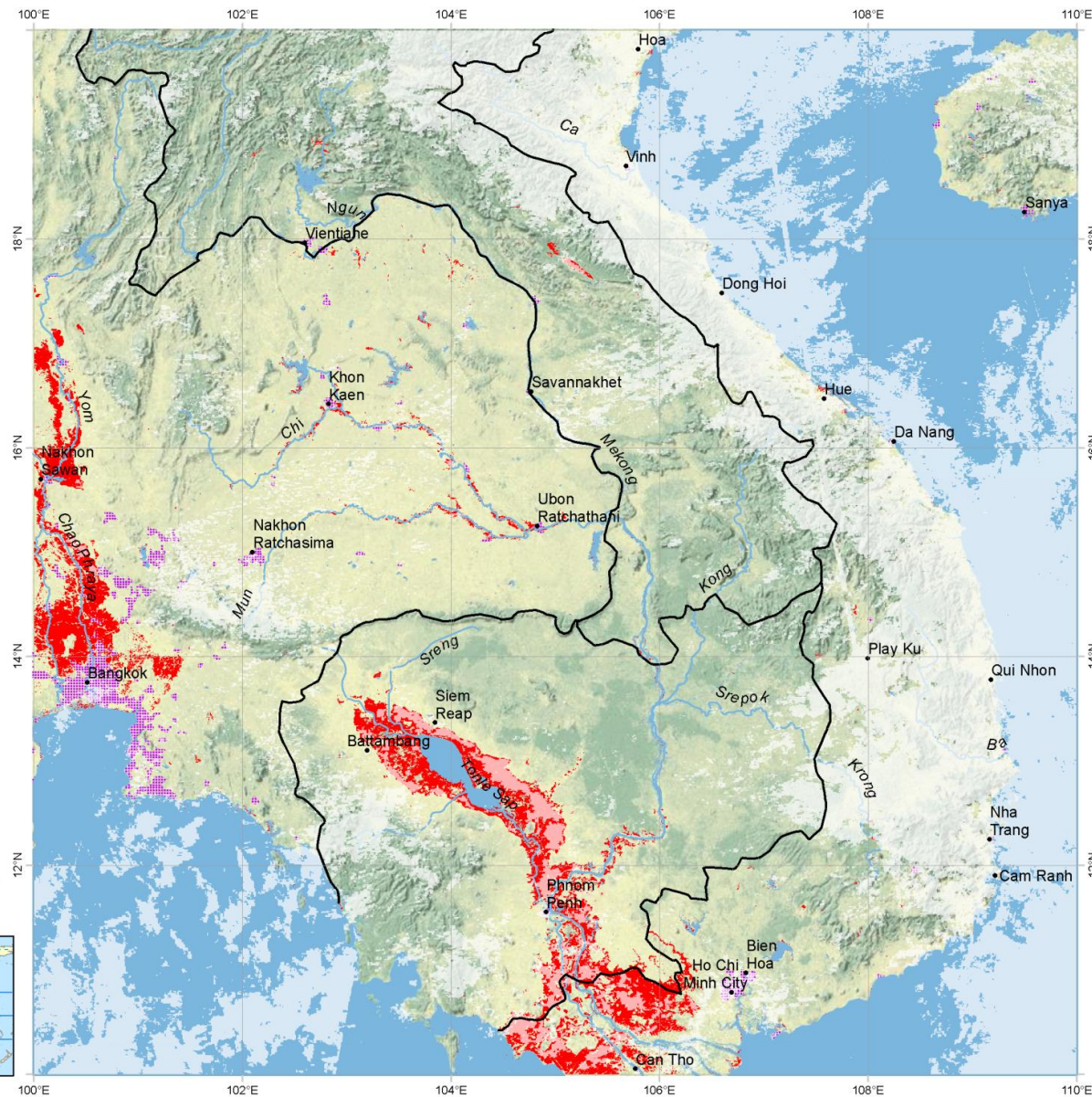
Plate Carree, WGS-84



Office of Applied Sciences
NASA Goddard Space Flight Center
Greenbelt MD 20771 USA

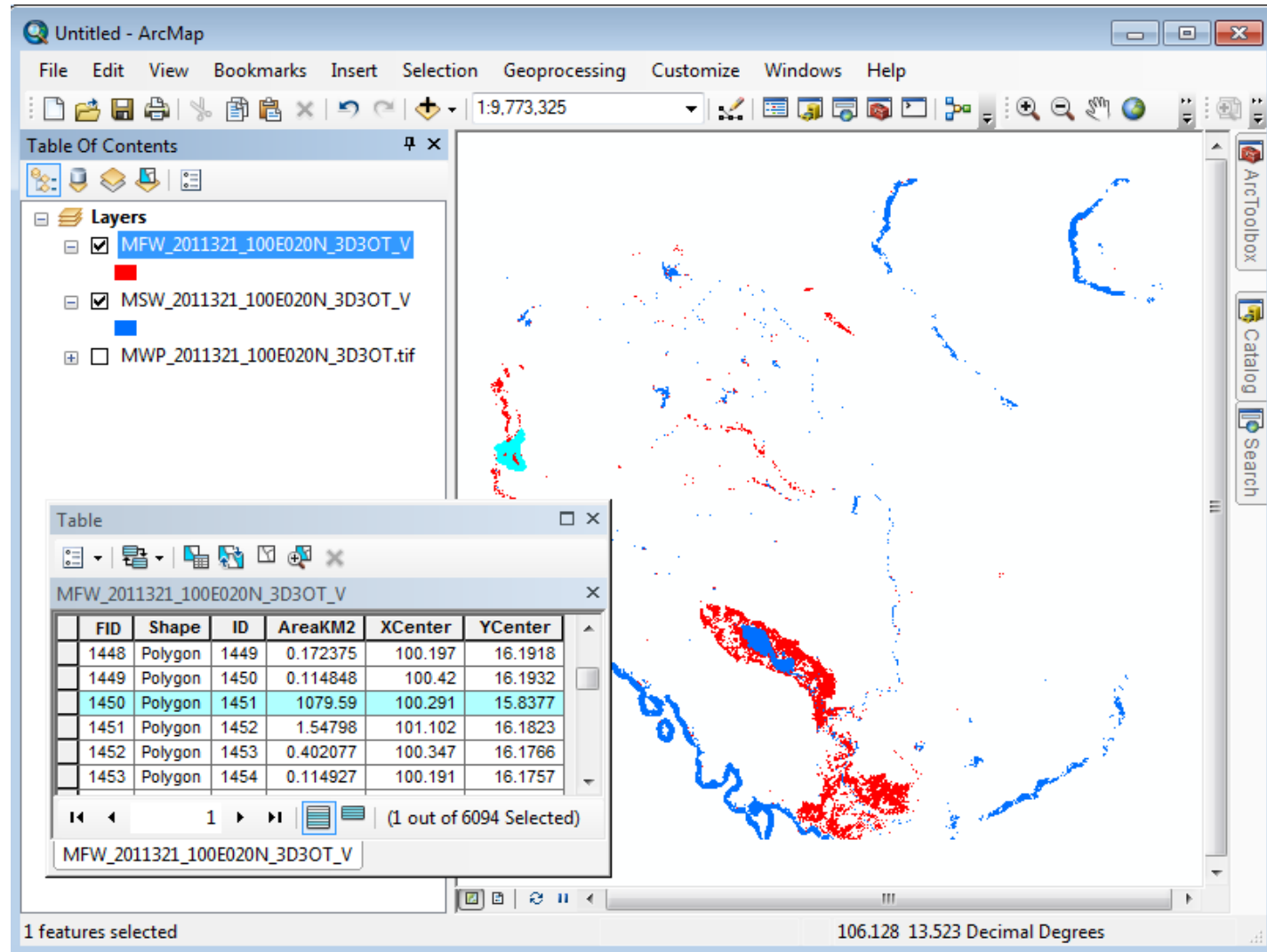


Product: 2D20 / 2011306
Generated: 15 Feb 2012 18:50:08 GMT



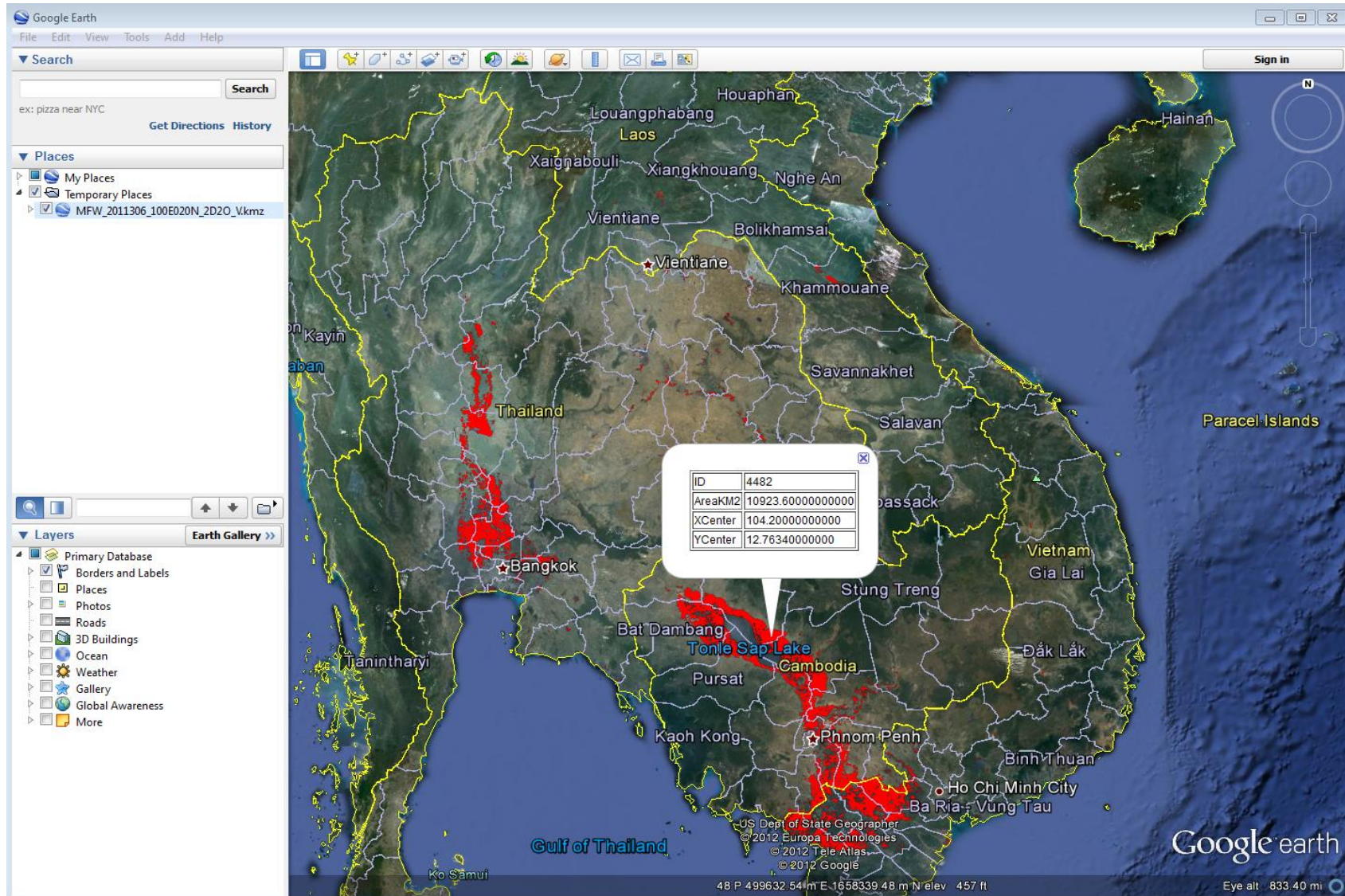
Products: MODIS Surface & Flood Water (MSW, MFW) shapefiles

- Vectorized from MWP (raster) product
- Does not indicate where insufficient data to determine (value 0 of MWP product)
- Provides area and centroid per polygon
- Production can fail if too many polygons
- KML production skipped if #polygons > 15000



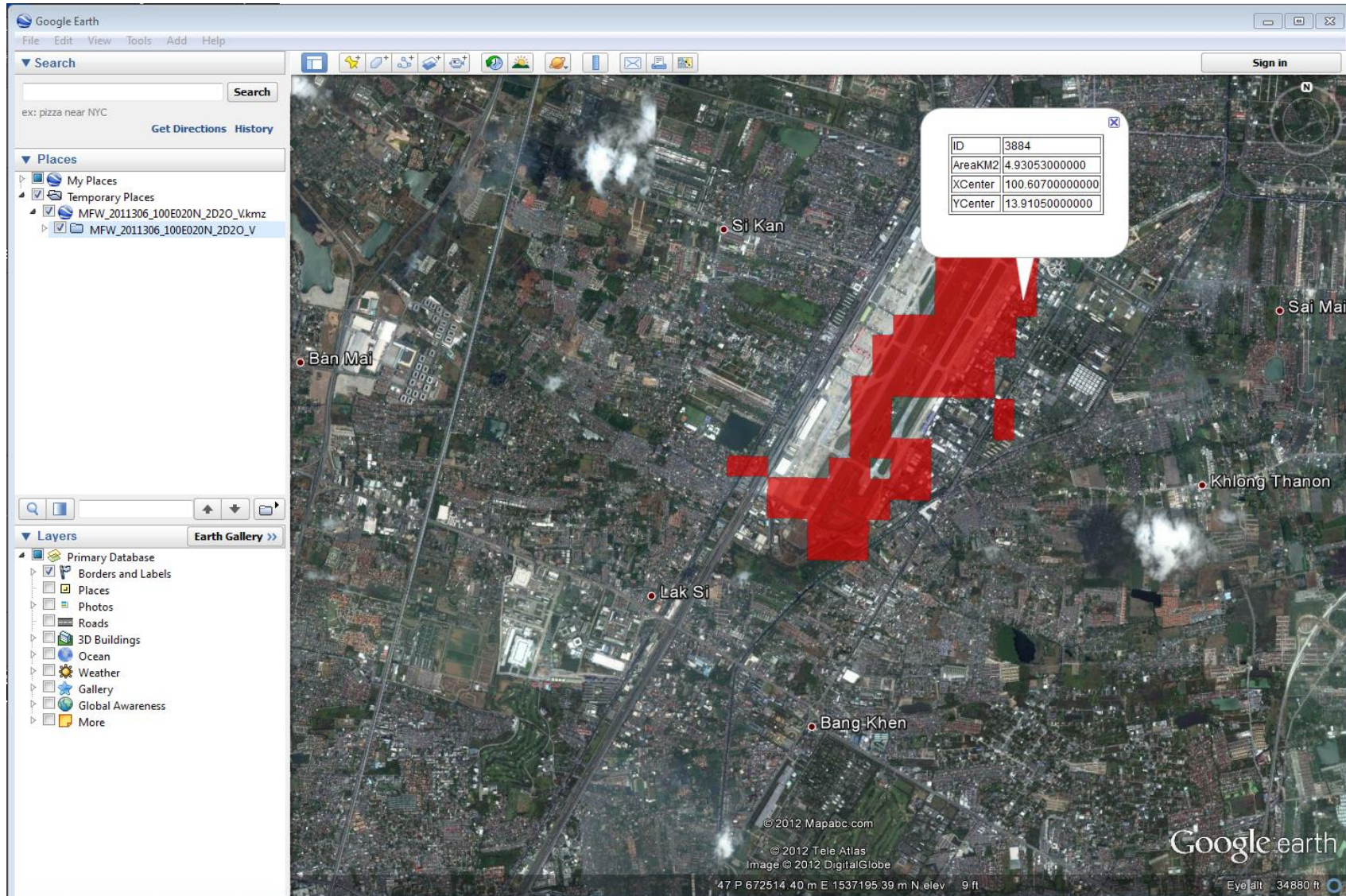
Products: MODIS Surface & Flood Water KML files (Google Earth)

KML files in Google Earth:



Products: MODIS Surface & Flood Water KML files (Google Earth)

Google Earth zoomed in -- Bangkok's Don Muang Airport runways under water:



MODIS Flood Product Evaluation

Purpose:

- Is water detection algorithm working
 - correctly detecting visually obvious water?
- Are certain situations problematic?
- Are the multi-day composited products working well?
- Differences between detection of flood water vs normal water

Evaluation method:

- Globally distributed flood and permanent water sites (~50 each)
- Visual and qualitative assessment of performance
 - raw MODIS and Landsat imagery used to help inform assessment

http://oas.gsfc.nasa.gov/floodmap/documents/NASAGlobalNRTEvaluationSummary_v4.pdf

Flood Detection Ratings

RATING	Count	%
5-almost perfect	11	21
4-excellent	10	19
3-good	2	4
2-fair	1	2
1-poor	11	21
TMC - too many clouds	17	33
Outside product coverage area	1	Eliminated from equation
TOTALS	53	100

} 66% of clear

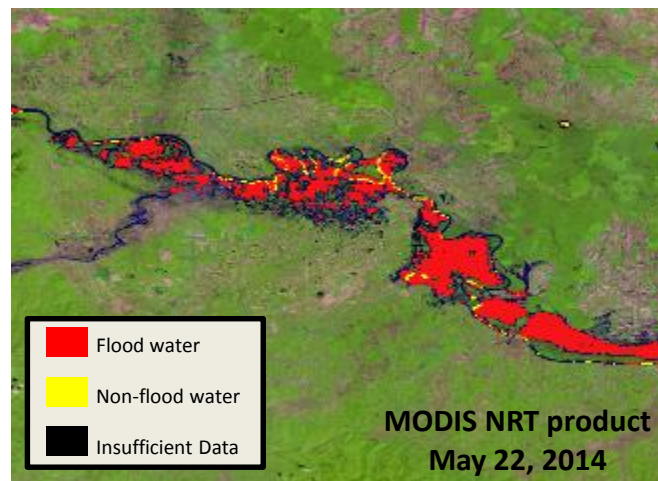
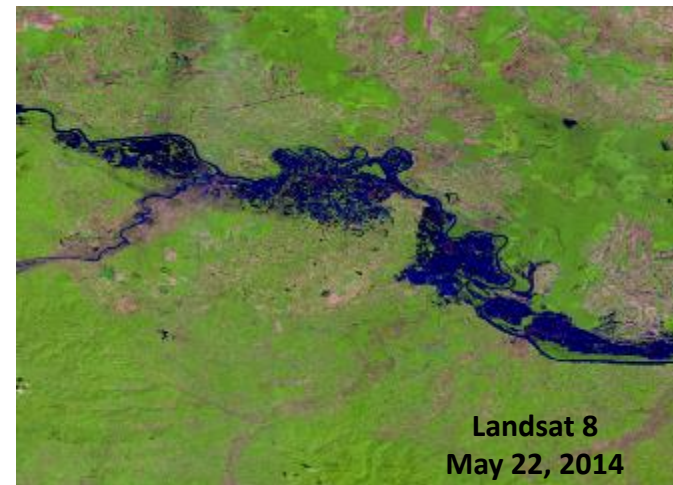
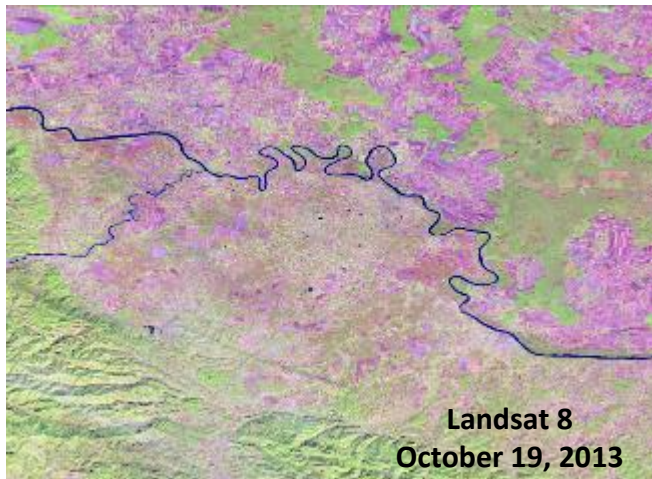
Permanent Water Detection Ratings

RATING	Count	%
5-almost perfect	15	28
4-excellent	9	17
3-good	7	13
2-fair	2	4
1-poor	4	8
TMC - too many clouds	16	30
Outside product coverage area	1	Eliminated from equation
TOTALS	54	100

} 84% of clear

Correct flood identification

Bosnia and Herzegovina: 22 May 2014



Correct flood and permanent water identification

Brazil: 02 January 2014



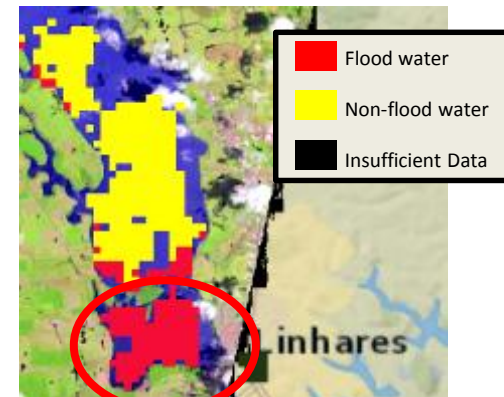
National Geographic
base map



Landsat 8 Pre-flood
Apr 21, 2013



Landsat 8 Flood
Jan 2, 2014



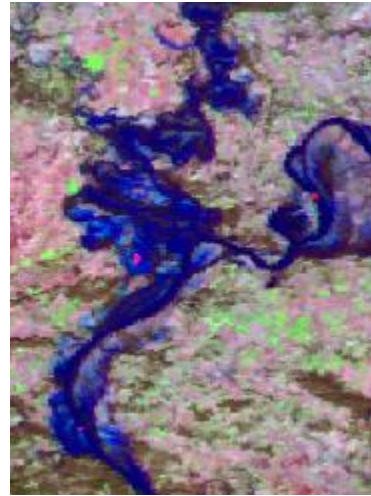
MODIS NRT product
Jan 3, 2014

Example: Correct flood identification

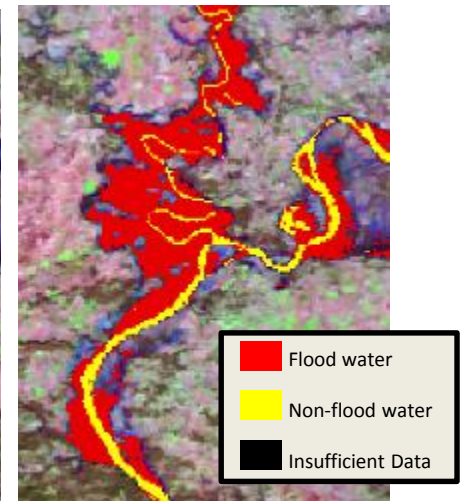
Kentucky: 04 Jan 2014



MODIS (MOD09) Pre-Flood
Oct 12, 2013



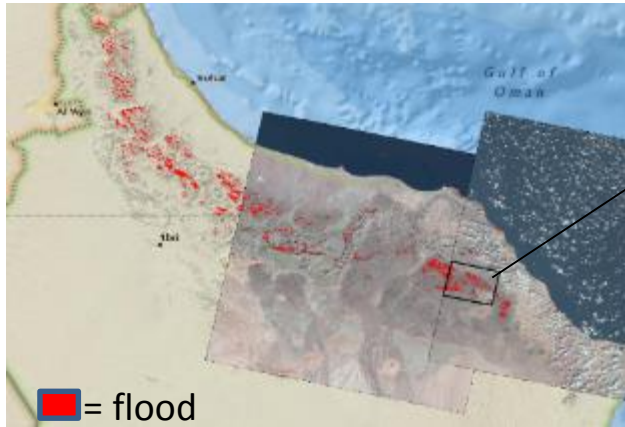
MODIS (MOD09) Flood
Jan 4, 2014



MODIS NRT Product
Jan 4, 2014

Terrain shadow false-positives

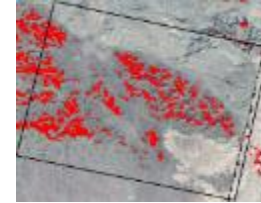
OMAN: mid November 2013 products



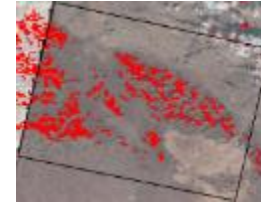
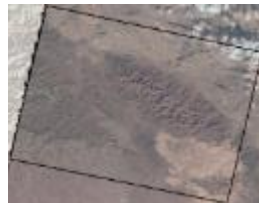
3-day product



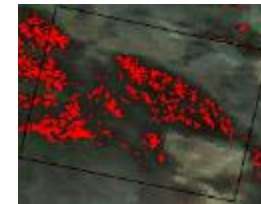
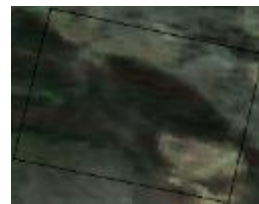
Landsat 8
June 17, 2013
(2013178)



Landsat 8
Nov 9, 2013
(2013313)



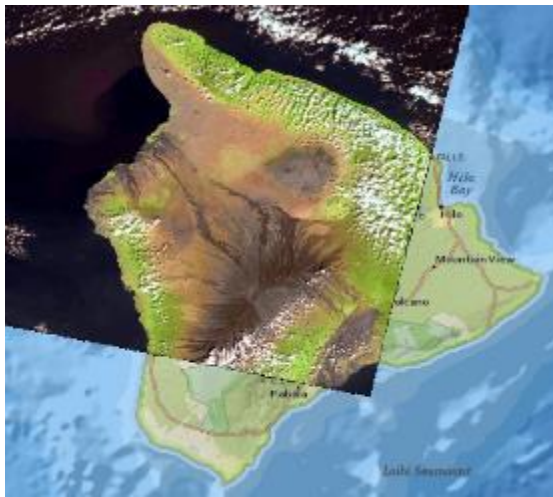
Landsat 8
Nov 18, 2013
(2013322)



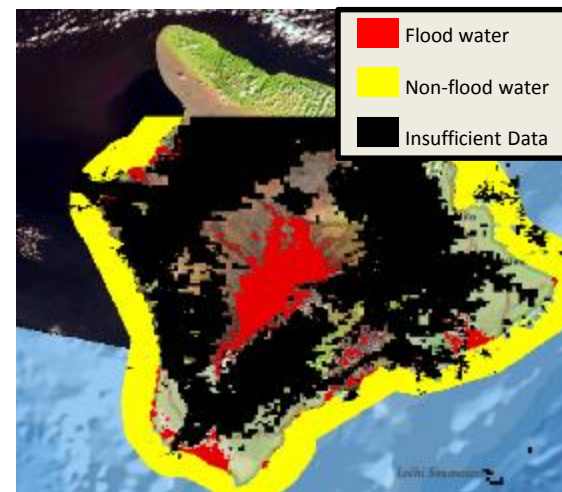
MODIS (MOD09)
Nov 11, 2013
(2013315)

Example: Barren rock / volcanic false positives

Mauna Loa, **Hawaii**: 17 Dec 2013



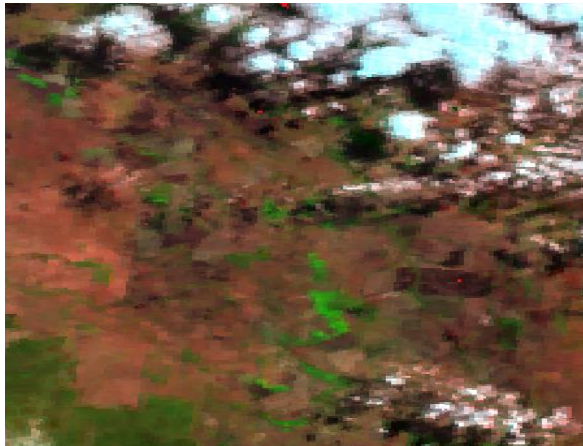
Landsat 8



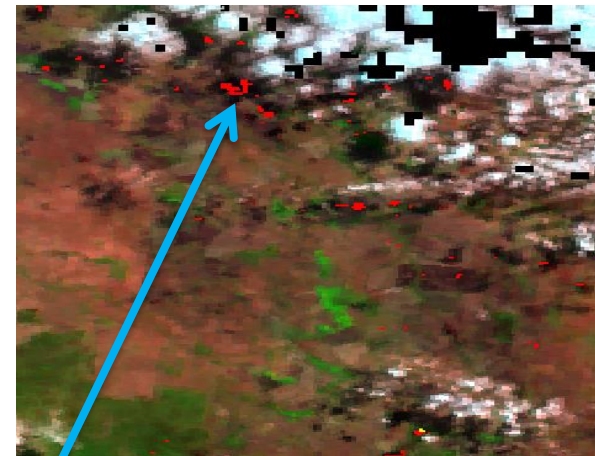
MODIS NRT Product

Example: Cloud shadow false-positives

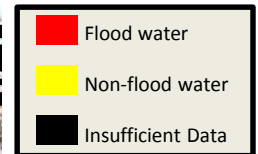
Australia: 04 July 2014



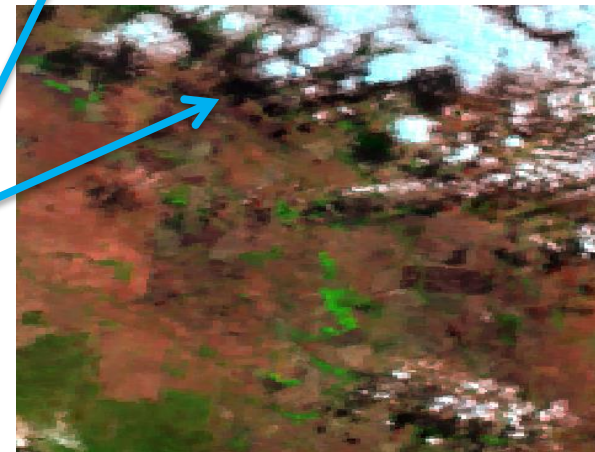
Input data: MOD09, 04 Jul 2014



2-day Product on MOD09



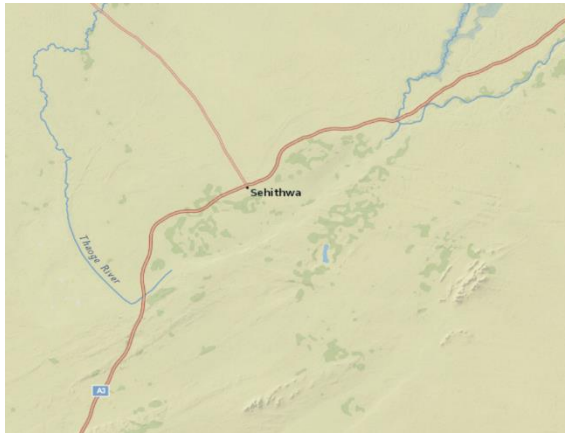
3-day product
removes most
cloud shadow
false positives



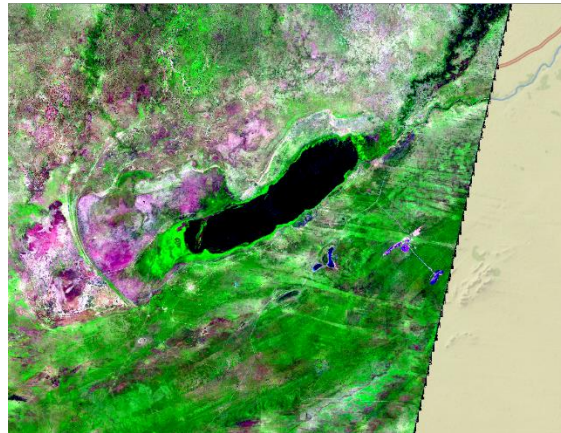
3-day Product

Comparison of different compositing periods: 2-day vs 3-day product

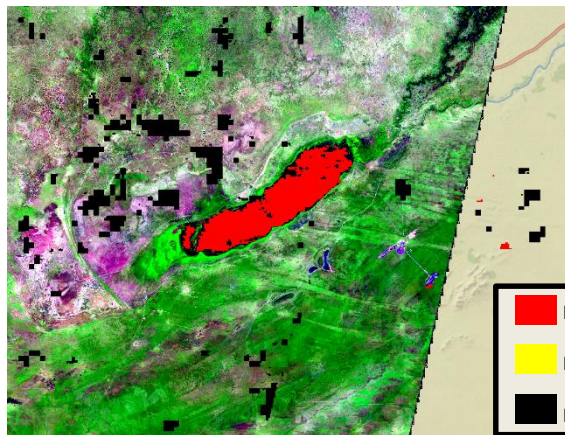
Botswana: 24 Mar 2014



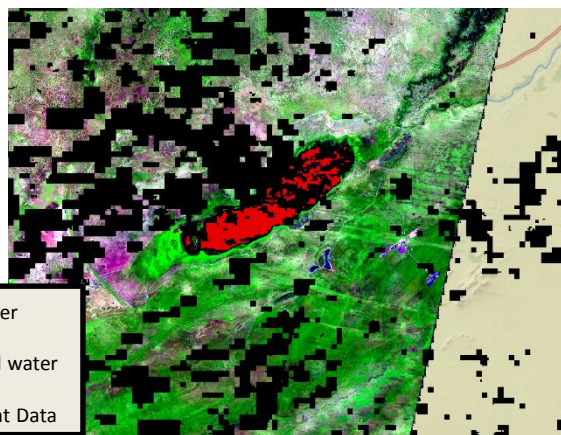
National Geographic base map



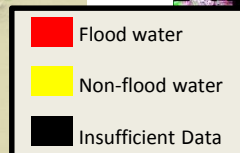
MODIS (MOD09) Mar 24, 2014



2-day product



3-day product



Which compositing period should I use?

Just how cloudy is it?

- It depends....basically on cloud conditions:
 - User tolerance for false positives (and false negatives)
 - User need for only the most up-to-date information
- Clear conditions? Use 2-day or 1-day.
- Very sensitive to false-positives? Use 3-day.
- Very sensitive to false-negatives (cloud)? Use 14-day.
- Need the latest info? Use 1-day.
- Best approach? Look at them all and evaluate for given event and needs.

Current efforts

- Recently transitioned flood map distribution to NASA LANCE
- Working transition of flood map production to NASA LANCE
- Improvements to MODIS product
 - Replace $10^\circ \times 10^\circ$ Tiles with swath data
 - Decreased latency
 - Improved masking of cloud and terrain shadows
 - Masking of high slope areas (HAND algorithm)
 - Ephemeral water mask (recurring water that is not unusual flooding)

Comments/ Questions ?